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(56) Publications considered in assessing patentability:

DE	34 38 154 C2	DE	94 14 689 U1
DE	43 21 823 A1	DE	94 14 689 U1
DE	43 11 937 A1	DE	94 14 688 U1
DE	39 29 477 A1	DE	93 03 327 U1

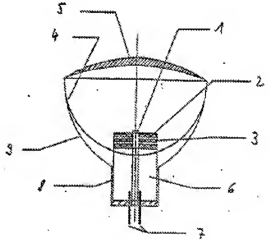
DE	92 06 859 U1
DE	89 02 905 U1
DE	82 33 195 U1
FR	26 28 823 A1
US	54 36 535

Thiele, Peter, "Was die hellste Leuchtdiode der Welt leistet" [What the World's Brightest Light-Emitting Diode Does], in F & M, Vol. 103, 1995, No. 1-2, pp. 63-66;

Möllmer, Frank, and Waitl, Günter, "SIEMENS SMT-TOPLED für die Oberflächenmontage" [Siemens SMT-TOPLED for Surface-Mount Installation], in Siemens Components 29, 1991, No. 5, pp. 193-196;

(54) **Illuminating Apparatus**

(57) The invention creates an illuminating apparatus having a plurality of substantially punctiform light source devices each of which radiates light in a preferred direction; a holding device in order to hold these punctiform light source devices in a substantially specified spatial relationship to one another, this spatial relationship being chosen such that at least two of these punctiform light source devices radiate their light in different directions; and an optical device that modifies the characteristics of the light radiated by these punctiform light source devices. The illuminating apparatus according to the invention can generate light with a higher radiant output and/or broader-band light.



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Description

The invention relates to an illuminating apparatus and in particular an illuminating apparatus having a plurality of substantially punctiform light source devices each of which radiates light in a preferred direction.

The invention further relates to the use of the illuminating apparatus according to the invention, a method for operating the illuminating apparatus according to the invention, and a colored-light system with the illuminating apparatus according to the invention.

Although the description that follows is restricted to light-emitting diodes (LEDs), any type of punctiform light sources can be employed for the construction of the illuminating apparatus according to the invention, in particular other punctiform semiconductor light sources such as for example semiconductor lasers or further semiconductor configurations that exhibit luminescence effects such as for example configurations of amorphous silicon, which have recently become known.

Light-emitting diodes, which are also referred to as luminescence diodes, are pn diodes employed as an optoelectronic semiconductor component, in which electroluminescence occurs at the pn junction. In most cases the light in question is visible light or infrared light.

Figure 18 shows three typical geometries A, B, and C of light-emitting diodes according to the prior art, which are commonly fabricated by the epitaxial growth method.

Form A in Figure 18 is a film configuration of a p-GaAs film 101 and an n-GaAs film 102, on the top and bottom of which contacts 103 are affixed. The contact on the top exhibits an aperture in the middle, which allows the light beam to exit in the direction of the arrow.

Form B in Figure 18 is a film configuration similar to form A, in which there is additionally an n-GaAs sphere 102 on the light beam exit aperture. This additional n-GaAs sphere 102 serves to focus the light emitted in the direction of the arrow.

Form C in Figure 18 is a film configuration similar to form A, in which the contact on the top has no aperture and accordingly the light beam exits laterally in the direction of the arrow.

In operation, the light-emitting diode is biased in the forward direction, so that the charge-carrier concentrations are higher than the equilibrium concentrations. The energy released in the recombination that occurs is radiated in the form of light.

Light-emitting diodes exist in a variety of colors, specifically in particular in infrared,

red, orange, yellow, green, and blue.

It is also possible to modify the color of the light emitted by a light-emitting diode by employing this light to excite a photoluminescent substance. For example, infrared light emitted by GaAs light-emitting diodes can be transformed into green light. Here the light-emitting diode is advantageously directly coated with the photoluminescent substance.

A special modification of the light-emitting diode is the semiconductor laser, in which recombination effects are stimulated after preliminary overpopulation of the conduction band.

Light-emitting diodes are designated, for example, as display components and as components of integrated solid-state image converters. Semiconductor lasers find use in laser displays and above all in laser printers. All these applications of known semiconductor light sources feature their property as a punctiform light source.

Figure 19 shows the typical structure of a light-emitting diode in a plastic housing as a punctiform light source according to the prior art.

The reference characters in Figure 19 have the following denotations: 104, an anode lead; 105, a cathode lead; 106, a bond wire; 107, an LED chip having for example form A of Figure 18; 108, a reflector cup; and 109, a plastic housing.

In recent years, since about 1990, LED technology has made advances in the direction of higher luminous efficiency (lumens per watt), chiefly in the region of visible wavelengths.

In comparison with conventional light sources such as for example incandescent bulbs with or without inert-gas filling, so-called superbright LEDs attain a much higher luminous efficiency. These superbright LEDs are on the market particularly in the colors red, yellow, light green, green, and blue. Work toward developing superbright LEDs for blue to green light, using GaN, and for yellow to red light, using AlInGaP, is being pushed intensively.

The radiant output of a single LED is, however, limited, a few watts being cited as the upper limit. What is more, LEDs radiate light only in a relatively narrow band of wavelengths; that is, all that can be generated with an LED is approximately monochromatic light at a relatively low radiant output.

Known from DE-OS 23 15 709 is a radiation-emitting planar semiconductor configuration with high radiant output. This known semiconductor configuration exhibits a housing base, which is insulating at least on the surface side facing toward the semiconductor configuration, and a radiation-transparent plastic lens covering the semiconductor configuration.

Arranged on the housing base are a large number of radiation-emitting semiconductor components, all of which are connected either in series or in parallel with one another.

Known from EP-A-0 390 479 is an LED cluster unit for a display device. This known LED cluster unit contains a matrix array of LEDs on a board, on the back of which plug connectors are affixed. On the radiation side of the LEDs there is a tubular shield device in order to shield the LED clusters from laterally incident light, so that the viewer can perceive a sharp image from the LED cluster. Further, the shield device is said to protect the LED clusters from contamination and damage.

It is a goal of the invention to create an improved illuminating apparatus that can generate light with higher radiant output and/or broader-band light.

According to the invention, the above goal is achieved with the subject of Claim 1.

Moreover, the invention provides for the employment of the illuminating apparatus according to the invention as set forth in Claims 45 to 48, 50 to 53, and 55.

Additionally, the invention creates a method for operating an illuminating apparatus according to the invention as set forth in Claim 56.

Further, the invention yields a colored-light system with the illuminating apparatus according to the invention as set forth in Claim 57.

Preferred developments are the subjects of the respective dependent claims.

The idea underlying the invention is to create, from a plurality of punctiform light sources, an illuminating apparatus generating light with higher radiant output and/or broader-band light by virtue of the fact that the punctiform light sources radiate their light in at least two distinct directions and that this radiated light is efficiently directed and/or blended as to color. In this way, far greater optical efficiencies (lumens per watt), also referred to as luminous efficiency, can be achieved than in the above-named conventional illuminating apparatuses.

Particularly advantageous points of the illuminating apparatus according to the invention are long service life, high luminous efficiency, the small rise in temperature over the surroundings, the possibility of color optimization, the possibility of modulating the radiated light, and the simplicity of packaging.

In what follows, exemplary embodiments of the invention are described in greater detail with reference to the drawings, wherein:

Figure 1 is a front view of an LED lamp according to a first preferred embodiment of the

invention;

Figure 2 is a top view of the LED lamp according to the first preferred embodiment of the invention;

Figure 3 is a front view of an exemplary LED holding structure for the first preferred embodiment of the invention;

Figure 4 is a top view of the exemplary LED holding structure for the first preferred embodiment of the invention;

Figures 5 to 7 show exemplary configurations of the LED emitter plates in the LED lamp according to the first preferred embodiment of the invention;

Figure 8 is a front view of an LED beam tube according to a second preferred embodiment of the invention;

Figure 9 is a top view of the LED beam tube according to the second preferred embodiment of the invention;

Figures 10 to 13 show exemplary configurations of the LED emitter plates in the LED beam tube according to the second preferred embodiment of the invention;

Figure 14 is a front view of an LED lamp according to a third preferred embodiment of the invention wherein the LED beam tube according to the second preferred embodiment is used in a reflector;

Figure 15 is an illustration for the purpose of estimating the area for the emitter boards of the illuminating apparatus according to the invention with the employment of LED chips customary in trade;

Figure 16 shows a colored-light element of a colored-light system according to a fourth preferred embodiment of the invention, with an enlarged detail top view and cross section;

Figure 17 is an electrical block diagram for the colored-light system according to the fourth preferred embodiment of the invention;

Figure 18 shows three typical geometric forms A, B and C of light-emitting diodes according to the known art, which are commonly fabricated by the epitaxial growth method; and

Figure 19 shows the typical construction of a light-emitting diode in a plastic housing as a point light source according to the known art.

In the Drawings, like reference characters denote like components, the description of which is not repeated.

Figure 1 is a front view of an LED lamp according to a first preferred embodiment of the invention.

The reference character 1 in Figure 1 denotes an emitter plate holder on which one or a plurality of emitter plates 2 having a multiplicity of LEDs 3 affixed thereto are held. This configuration is located in a reflector 4 for homogeneous beam blending. LEDs 3 are distributed in a three-dimensional configuration on emitter plate or plates 2 in such fashion that the light emitted from them is incident on reflector 4.

Reflector 4 directs the light of LEDs 3 to its exit aperture, which advantageously has a transparent covering 5.

LEDs 3 can have the same or different wavelengths. In the case of different wavelengths of LEDs 3, homogeneous color blending of light having different wavelengths can be achieved by appropriate fashioning of reflector 4 as a diffuser, in order in this way to obtain, for example, white light from the three primary colors red, green, and blue. Any other color blends are also conceivable in correspondence with the distribution of the various wavelengths.

Transparent covering 5 can advantageously contain a convergent lens to condense the light radiation or a divergent lens to disperse it and adjust the angle of radiation.

Reflector 4 in turn is held in a reflector body 5. At the foot of reflector body 5, a controller board part 6 having current contacts 7 extending outwardly from reflector 5 is advantageously embedded in a casting compound 8.

The overall design of the LED beam tube according to the first preferred embodiment of the invention is thus similar to that of a conventional halogen lamp.

Power can be supplied via a current or voltage regulator, a rectifier in the case of an AC connection, a transient protection circuit, or a pulse control circuit. All such regulating or control circuits can either be integrated on controller board part 6 or provided separately outside the LED lamp.

When LEDs 3 are supplied with current, the light emitted by them falls on reflector 4 and is homogeneously directed to the exit aperture or additionally blended as to color and condensed, so that the observer of the light beam radiated by the LED lamp can no longer recognize that the light originally arose from individual punctiform semiconductor light sources, for example LEDs 3.

There are numerous possibilities for electrically exciting various subgroups of the

multiplicity of LEDs 3 in such fashion that distinct brightness, color, or light-frequency modulation effects can be achieved, which effects will be described in greater detail further below.

The individual LEDs can also be mechanically adjustable as to their configuration by an appropriate device in order to obtain such modulation effects.

The LED lamp with the three-dimensional LED configuration according to the first preferred embodiment of the invention emits light with high radiant output and/or broader-band light than the known apparatuses having planar LED configurations, and in this way the requirement for large radiating areas for high radiant outputs is eliminated.

Table 1 below summarizes the materials that can be employed for the individual components of the LED lamp according to the first preferred embodiment of the invention as illustrated in Figures 1 and 2.

Table 1. Materials for the Components of the LED Lamp
According to the First Preferred Embodiment of the Invention

Component	Material
Reflector body 9	Plastics such as for example Plexiglas, polycarbonate, glass
Reflector 4, diffuser	Vapor-deposited metals, reflective paint
Covering 5, convergent lens	Clear plastics such as for example Plexiglas, glass
Board holder 12	Plastics, glass, ceramic (green ceramic is readily machinable), metals
Board 10	Copper-coated glass-fiber-reinforced plastic (surface-mount technology), ceramic such as Al_2O_3 (thick-film technology), metal-coated glass (thin-film technology)

Figure 2 is a top view of the LED lamp according to the first preferred embodiment of the invention.

As can be seen from Figure 2, emitter plate holder 1 is preferably located on the longitudinal axis of reflector 4. Emitter plates 2 are preferably planar and bear a multiplicity of LEDs 3 on both sides facing toward reflector 4 in order in this way to form the three-dimensional

LED configuration.

Figure 3 is a front view of an exemplary LED holding structure for the first preferred embodiment of the invention.

LEDs 3 affixed to emitter plate 2 are in turn located on commercially available boards 10, whereon they are connected in series, in parallel or in a mixed network. Boards 10 are connected to the controller electronics and the terminal board part.

Figure 4 is a top view of the exemplary LED holding structure for the first preferred embodiment of the invention.

As can be seen from Figure 4, emitter plate 2 preferably comprises a plate-shaped board holder 12 to both sides of which boards 10 with LEDs 3 are attached using a suitable adhesive 13. Plate-shaped board holder 12 in turn is connected in suitable fashion to emitter plate holder 1, for example by a slot in emitter plate holder 1.

Controller board part 6 can be affixed to plate-shaped board holder 12 in exactly the same manner as boards 10.

Figures 5 to 7 show exemplary configurations of LED emitter plates 2 in the LED lamp according to the first preferred embodiment of the invention.

The configuration of Figure 5 provides two emitter plates 2 each having two boards, which are arranged at an angle of 180° to each other. If it is considered that even a punctiform light source such as an LED has a finite beam angle, then even this simple configuration makes it possible to irradiate nearly the whole internal surface of reflector 4. The radiant output of an LED lamp attainable in this way is, however, still relatively low.

The configuration of Figure 6 provides three emitter plates 2 each having two boards, which are arranged at an angle of 120° to one another. Such a configuration offers a higher radiant output because here the internal surface of reflector 4 is more intensely irradiated.

The configuration of Figure 7, which provides four emitter plates 2 each having two boards, which are arranged at an angle of 90° to one another, offers still more intense irradiation.

The irradiation can be further boosted by appropriately decreasing the angle between individual emitter plates 2, but it must be kept in mind that disturbing optical and thermal interactions between individual LEDs can occur as the angles become smaller and smaller.

Figure 8 is a front view of an LED beam tube according to a second preferred embodiment of the invention.

The reference character 20 in Figure 8 denotes a board having a multiplicity of LEDs 3 affixed thereto. A plurality of boards 20 having LEDs 3 are provided in a three-dimensional configuration enclosed by an envelope tube 24 in such fashion that the light emitted by them is incident on envelope tube 24. Envelope tube 24 allows the light of LEDs 3 to pass outwardly through its transparent exit region.

Envelope tube 24 is advantageously cylindrical, with the exit region running all around the cylindrical surface. In this configuration there are advantageously reflector disks 25 respectively axially above and below boards 20, which reflector disks direct the light of LEDs 3 to the exit region of envelope tube 24.

LEDs 3 can exhibit the same or different wavelengths. In the case of different wavelengths of LEDs 3, homogeneous color blending of the light differing in wavelength can be achieved by appropriate fashioning of envelope tube 24 as a diffuser in order in this way to obtain, for example, white light from the three primary colors red, green, and blue. Any other color blends are also conceivable in correspondence with the distribution of the various wavelengths.

At the top end of envelope tube 24 there is preferably an envelope tube cap, it being possible at the same time for upper reflector disk 25 to take over this function.

At the bottom end of envelope tube 24 a base 26 is preferably affixed, which base is for example a screw or pin base. A controller board part 27 having current contacts 28 extending to the surface of base 26 is preferably embedded in a casting compound in base 26.

The overall design of the LED beam tube according to the second preferred embodiment of the invention is thus similar to that of a conventional incandescent bulb.

The electrical excitation and mechanical adjustment of the LED beam tube according to the second preferred embodiment of the invention can be effected exactly as in the case of the first embodiment.

Figure 9 is a top view of the LED beam tube according to the second preferred embodiment of the invention.

As can be seen from Figure 9, there is a board holder 29 on the back of boards 20 with LEDs 3. In the example shown here, four boards 20 having LEDs 3 pointing to the exit region of envelope tube 24 at an angle of 90° to one another are affixed to board holder 29 running along the longitudinal axis of envelope tube 24.

Table 2 below summarizes the materials that can be employed for the individual components of the LED lamp according to the second preferred embodiment of the invention as illustrated in Figures 8 and 9.

Table 2. Materials for the Components of the LED Lamp
According to the Second Preferred Embodiment of the Invention

Component	Material
Envelope tube cap	Ceramic, glass, metals
Reflector disk 25	Vapor-deposited metals, reflective paint
Envelope tube 24, diffuser	Plexiglas, glass
Board holder 29	Plastics, glass, ceramic (green ceramic is readily machinable), metals
Boards 20	Copper-coated glass-fiber-reinforced plastic (surface-mount technology), ceramic such as Al_2O_3 (thick-film technology), metal-coated glass (thin-film technology)

Figures 10 to 13 show exemplary configurations of the LED emitter plates in the LED beam tube according to the second preferred embodiment of the invention.

The configuration of Figure 10 provides two boards 20, which are attached at an angle of 180° with backs facing together on a planar board holder 29. If it is considered that even a punctiform light source such as an LED has a finite beam angle, then even this simple configuration makes it possible to irradiate nearly the entire internal surface of envelope tube 24. The radiant output of the LED lamp attainable in this way is, however, still relatively low.

The configuration of Figure 11 provides three boards 20, which are attached at an angle of 120° with backs facing together on a triangular board holder 29. Such a configuration offers a higher radiant output, because here the internal surface of envelope tube 24 is more intensely irradiated.

Still more intense irradiation is offered by the configuration of Figure 12, which provides four boards 20 attached at an angle of 90° with backs facing together to a rectangular board holder 29.

Still more intense irradiation is offered by the configuration of Figure 13, which provides

eight boards 20, which are attached in star fashion with backs facing together to a cruciform board holder 29.

As in the first embodiment, the irradiation can be further boosted by appropriately diminishing the angle between individual emitter plates 2, but it must be kept in mind that disturbing optical and thermal interactions between the individual LEDs can occur as the angles become smaller and smaller.

Figure 14 is a front view of an LED lamp according to a third preferred embodiment of the invention, wherein the LED beam tube according to the second preferred embodiment, as illustrated in Figures 8 and 9, is used in a reflector.

The reference character 30 in Figure 14 denotes generally the LED beam tube according to the second preferred embodiment as illustrated in Figures 8 and 9. LED beam tube 50, which in the example shown contains four boards with LEDs in a square configuration, is inserted into a reflector 31. At its foot, reflector 31 also exhibits an appropriate reflector body 32, into which LED beam tube 30 is preferably screwed or plugged.

As in the first embodiment, reflector 31 directs the light of LED beam tube 30 to its exit aperture, which preferably exhibits a transparent covering 33.

Transparent covering 33 can advantageously contain a convergent lens to condense the light radiation or a divergent lens to disperse it and adjust the angle of radiation.

Power is supplied to LED beam tube 30 via current contacts 34 on the bottom of reflector body 32.

In the third embodiment according to Figure 14, the beam can be realigned after blending of the color components on the envelope tube, so as to improve still further the homogeneity of the beam.

The electrical excitation and mechanical adjustment of the LED beam tube according to the third preferred embodiment of the invention can be effected exactly as in the case of the first and second embodiments.

Figure 15 is an illustration for the purpose of estimating the area for the emitter boards of the illuminating apparatus according to the invention with the employment of LED chips customary in trade.

With the use of LED chips customary in trade having dimensions larger than 0.5 mm × 0.5 mm, a linear configuration of three LED chips (Nos. 1-3) having associated conductive paths

can be mounted on an area of approximately 8.50 mm × 4.55 mm.

Two such linear configurations of 2 × 3 LED chips (Nos. 1-3 and 4-6) lying side by side require an area of approximately 8.50 mm × 7.55 mm, and three such linear configurations of 3 × 3 LED chips (Nos. 1-3, 4-6 and 7-9) lying side by side require an area of approximately 8.50 mm × 11.20 mm.

Depending on the space available, the emitter boards can be both widened and lengthened and the radiant output increased. An enlargement in the third dimension, when possible, will, however, be preferred in order to avoid the necessity of compromise in terms of compactness.

Table 3 below shows technologies for fabricating emitter boards for various LED styles.

Table 3. Technologies for the Fabrication of Emitter Boards
for Various LED Designs

LED Designs	Technology for Fabrication
Chip LED (not encapsulated)	Chip-and-wire technology (mounting of chips with conductive adhesive and use of bonding for connections)
SM chip LED and SM lamps (encapsulated)	Copper SM technology and thick-film technology on ceramic substrate, reflow soldering

The salient advantages of the illuminating apparatus according to the invention in comparison with conventional filament incandescent lamps open up to the former a large number of potential future applications.

Among the potential applications are in particular battery-powered lights such as for example flashlights, studio lamps (currently halogen lamps), headlights or other lights for motor vehicles and bicycles, UV and infrared lights.

Further, uses as pulsed lights for blue light, yellow lights, etc., of commercial vehicles and for flashlamps in photographic technology or stroboscopy are conceivable.

The existing art in LED fabrication and in particular the favorable price development of red, yellow, green, and blue LEDs in mass production suggest applications

— for use in the automotive industry as brake and backup light or blinker light;

— for use in traffic engineering as hanging signal light or warning light; and

— for use in optical data storage and data transmission technologies

as immediately obvious.

Integrated control-circuit technology in conjunction with LEDs on chips means that the combination of LEDs plus control electronics leads to the utmost miniaturization of components and sets a new standard in illumination systems technology.

For example, the illuminating apparatus according to the invention is outstandingly suitable as a component for a colored-light system for dynamic colored-light design in rooms.

Figure 16 shows a colored-light element of such a colored-light system according to a fourth preferred embodiment of the invention, with an enlarged detail top view and cross section.

In the example shown, the emitter board holder and the emitter boards are integrated into a ceramic block 40 having a rectangular cross section, to whose four lateral faces LEDs 43 are affixed and conductive paths 45 are applied for the connections.

On each lateral face of ceramic block 40, a perforated plate 42 having preferably round holes is affixed in such fashion that a red-green-blue LED triplet, designated by R,G,B, is inserted into each lateral depression so produced. The depressions can be cast full of a transparent plastic 47 in order to protect the LEDs and conductive paths located therein.

The individual LED chips are electrically connected in such fashion that red, green, and blue are to be excited separately, and indeed either for each LED triplet or at least for all LEDs matching one another in color. The red-green-blue LED lamp so constructed therefore requires at least four electrical leads, specifically one each for red, green, blue and ground.

As in the first embodiment, the light of the excited LEDs falls on a reflector 44 surrounding ceramic block 40 with the LEDs, which reflector directs the light to its exit aperture, preferably provided with a transparent covering 45.

Transparent covering 45 can advantageously contain a convergent lens to condense the light radiation or a divergent lens to disperse it and adjust the angle of radiation.

Ceramic block 40 intrudes into a base 46 provided below reflector 44, which base can have a plurality of functions.

First, base 46 holds the red-green-blue LED lamp so constructed; further, it advantageously contains the electronics of the colored-light element, which will be explained in greater detail further below in connection with Figure 17.

The detail enlargement shows, in top view and in cross section, LED chip triplet Nos. 1,

2, and 3 and their conductive paths 45 in enlarged representation. The decimal numbers in the detail enlargement give typical orders of size of the LED chips, the depressions and the thickness of the perforated plate in millimeters.

Figure 17 is an electrical block diagram for the colored-light system according to the fourth preferred embodiment of the invention.

In Figure 17, base 46 is illustrated with its external signal lines, the electronics contained therein and the red-green-blue LED lamp affixed thereto. For simplicity let it be assumed that all the LEDs matching one another in color are connected in series.

Led to base 46 externally are, for example, a DC supply voltage line and an AC supply voltage line 50 and 51, respectively; a bus line 52 for connection to a central processing unit; an infrared control line 53 from an infrared receiver affixed thereto for the separate wireless switching of the program of a color processor 56; and a sensor connecting line 54, for example for a microphone.

Internally, base 46 contains a voltage transformer 55 for AC power connection; color processor 56; an analog-to-digital converter 57 on the input side for converting signals passed on via sensor connection line 54; and three digital-to-analog converters 61, 62, 63 optionally having three current sources 64, 65, 66 connected in series therewith for exciting the three LED series networks corresponding to the three primary colors red, green, and blue.

The nucleus of the electronics located in base 46 is color processor 56. It controls the R,G,B LED lamp using the signals supplied to it and its own programs.

The base control function is, for example, a pulsed-current operating mode with a duty cycle optimized for the LEDs employed. This causes the optical efficiency of the LEDs to be improved in comparison with steady-current operating mode and furthermore protects them against overload.

Various programmable functions can be overlaid on the base control function, specifically for example

— turn individual LED colors on and off;

— modify the pulse rate of one or a plurality of LED series networks;

— modulate brightness, color, or frequency as a function of time.

Programs stored in the color process can be activated and deactivated or even modified via bus line 52 or infrared control line 53.

Sensor line 54 makes possible, for example, brightness, color, or frequency modulations as a function of time, depending on signals received by the microphone (light organ principle).

Table 4 below lists some controllable functions of the R,G,B LED lamp according to the invention.

Table 4. Some Controllable Functions of the R,G,B LED Lamp According to the Invention

Function
Fixed R,G,B colors
Fixed blended colors blended from R,G,B
Slowly (continuously) varying blended colors blended from R,G,B
Rapidly (abruptly) varying blended colors blended from R,G,B
Pulsating R,G,B colors
Pulsating blended colors blended from R,G,B
Repetition of specially chosen colors
Variable brightness
Modulation controlled by external sensor signals (e.g., microphone); example: sound/color linking or loudness linking

Individual R,G,B LED lamps can be combined into a centrally controlled colored-light system differing in excitation capabilities. Special functions in the system can be allocated to individual R,G,B LED lamps. Control can be exerted externally both via the bus line and also via a remote control.

Program commands from the central processor to the individual R,G,B LED lamps are preferably transmitted via the bus line, and individual functions of certain color processors are activated or deactivated with the remote control.

Such a colored-light system reveals versatile potential uses because each R,G,B LED lamp is a self-contained functional unit.

For example, objects in rooms or the actual rooms can be provided with spot or general lighting in the most varied ways using the electronic processor-controlled colored-light system according to the invention, with no additional mechanical effort.

Potential applications are found particularly

— in rooms where art objects are exhibited, for example picture galleries or museums;

— in rooms where technical or commercial objects are exhibited, for example industrial shows;

— in rooms in technical use, such as photographic laboratories; and

— for individual colored-light design in studios and living spaces.

The colored-light system according to the invention renders costly color-filter controls, which derive colored light from white light in conventional colored-light systems, completely superfluous and thus makes a substantial contribution to the rationalization of such systems.

Claims

1. Illuminating apparatus having:

a) a plurality of substantially punctiform light source devices each of which radiates light in a preferred direction;

b) a holding device for holding these punctiform light source devices in a substantially specified spatial relationship to one another, this spatial relationship being chosen such that at least two of these punctiform light source devices radiate their light in different directions; and

c) an optical device that modifies the characteristics of the light radiated by these punctiform light source devices.

2. Illuminating apparatus according to Claim 1, characterized in that the optical device contains a directing device that directs the light emitted by the punctiform light source devices into a predetermined direction.

3. Illuminating apparatus according to Claim 2, characterized in that the directing device directs the light emitted by the punctiform light source devices into the predetermined direction by reflection.

4. Illuminating apparatus according to Claims 1, 2, or 3, characterized in that the optical device contains a blending device that blends the light emitted by the punctiform light source

devices as to color.

5. Illuminating apparatus according to Claim 4, characterized in that the blending device blends the light emitted by the punctiform light source devices by diffuse transmission.

6. Illuminating apparatus according to Claims 4 or 5, characterized in that the blending device blends the light emitted by the punctiform light source devices by diffuse reflection.

7. Illuminating apparatus according to one of the foregoing claims, characterized by a condensing device for condensing the light modified by the optical device.

8. Illuminating apparatus according to one of the foregoing claims, characterized by a dispersing device for dispersing the light modified by the optical device.

9. Illuminating apparatus according to one of the foregoing claims, characterized in that a plurality of punctiform light source devices radiate their light in the same direction in each case.

10. Illuminating apparatus according to Claim 9, characterized in that each plurality of punctiform light source devices radiating their light in the same direction are affixed to a planar plate.

11. Illuminating apparatus according to Claim 10, characterized in that there are a plurality of planar plates each with a plurality of punctiform light source devices.

12. Illuminating apparatus according to Claim 11, characterized in that there is a group of two planar plates configured back to back on a support in such fashion that the punctiform light source devices affixed thereto radiate their light in two opposite directions.

13. Illuminating apparatus according to Claim 12, characterized in that there are a plurality of groups angularly offset relative to one another, each group having two planar plates, the two plates of each group being configured back to back on a support in such fashion that the

punctiform light source devices affixed thereto radiate their light in two opposite directions.

14. Illuminating apparatus according to Claim 13, characterized in that there are two groups that are angularly offset by 180° relative to each other.

15. Illuminating apparatus according to Claim 13, characterized in that there are three groups that are angularly offset by 120° relative to one another.

16. Illuminating apparatus according to Claim 13, characterized in that there are four groups that are angularly offset by 90° relative to one another.

17. Illuminating apparatus according to Claim 13, characterized in that there are n groups that are angularly offset by 360°/n relative to one another, n being a natural number larger than four.

18. Illuminating apparatus according to Claim 11, characterized in that there are three planar plates, which are configured on a triangular support in such fashion that the punctiform light source devices affixed thereto radiate their light in one of three directions offset in angle by 120°.

19. Illuminating apparatus according to Claim 11, characterized in that there are four planar plates, which are configured on a square support in such fashion that the punctiform light source devices affixed thereto radiate their light in one of four directions angularly offset by 90°.

20. Illuminating apparatus according to Claim 11, characterized in that there are eight planar plates, which are configured on a star-shaped support in such fashion that the punctiform light source devices affixed thereto radiate their light in one of eight corresponding directions.

21. Illuminating apparatus according to one of the foregoing claims, characterized in that the optical device contains a reflector device that reflects the light radiated by the punctiform light source devices.

22. Illuminating apparatus according to Claim 21, characterized in that the reflector device diffusely reflects the light radiated by the punctiform light source devices.

23. Illuminating apparatus according to Claim 21 or 22, characterized in that the reflector device is curved and the punctiform light source devices are configured inside the concave region of the curvature.

24. Illuminating apparatus according to one of Claims 21 to 23, characterized in that the condensing device or dispersing device is a lens device affixed in the radiation aperture of the reflector device.

25. Illuminating apparatus according to one of Claims 21 to 24, characterized in that the reflector device is mounted in a reflector holder.

26. Illuminating apparatus according to one of the foregoing claims, characterized in that there are regulating and/or control electronics.

27. Illuminating apparatus according to Claim 26, characterized in that the regulating and/or control electronics are mounted in the reflector holder.

28. Illuminating apparatus according to Claim 26 or 27, characterized in that the regulating or control electronics are located on a board that is cast with a casting compound.

29. Illuminating apparatus according to Claim 28, characterized in that the board can be connected to a power source via current contacts extending outwardly through the reflector holder.

30. Illuminating apparatus according to one of the foregoing claims, characterized in that the optical device contains a transparent envelope device that encloses the punctiform light source devices.

31. Illuminating apparatus according to Claim 30, characterized in that the transparent envelope device diffusely transmits the light radiated by the punctiform light source devices.

32. Illuminating apparatus according to Claim 30 or 31, characterized in that the transparent envelope device is tubular.

33. Illuminating apparatus according to Claim 32, characterized in that there is a reflector device in the envelope tube device axially above and/or axially below the punctiform light source devices.

34. Illuminating apparatus according to Claim 32 or 33, characterized in that there is an envelope tube cap at one end of the envelope device.

35. Illuminating apparatus according to one of Claims 32 to 34, characterized in that there is a connecting base device at one end of the envelope device.

36. Illuminating apparatus according to Claim 35, characterized in that the regulating and/or control electronics are mounted in the connecting base device.

37. Illuminating apparatus according to Claim 35 or 36, characterized in that the connecting base device contains a screw base.

38. Illuminating apparatus according to Claim 35 or 36, characterized in that the connecting base device contains a pin base.

39. Illuminating apparatus according to one of Claims 30 to 38, characterized in that the envelope device with the punctiform light source devices enclosed thereby is affixed in a curved reflector device inside the concave region of the curvature.

40. Illuminating apparatus according to Claim 39, characterized in that the condensing

device or dispersing device is a lens device affixed on the radiation aperture of the curved reflector device.

41. Illuminating apparatus according to one of the foregoing claims, characterized in that the punctiform light source devices are semiconductor light sources.

42. Illuminating apparatus according to Claim 41, characterized in that the semiconductor light sources comprise light-emitting diodes.

43. Illuminating apparatus according to Claim 41 or 42, characterized in that the semiconductor light sources comprise semiconductor lasers.

44. Illuminating apparatus according to one of the foregoing claims, characterized by a relationship-modifying device for modifying the specified spatial relationship of the punctiform light source devices.

45. Employment of an illuminating apparatus of one of Claims 1 to 44 in a battery-powered light.

46 Employment of an illuminating apparatus of one of Claims 1 to 44 in a studio lamp.

47. Employment of an illuminating apparatus of one of Claims 1 to 44 in a motor vehicle.

48. Employment of an illuminating apparatus of one of Claims 1 to 44 on a bicycle.

49. Employment according to Claim 47 or 48 as a headlight, as a backup light, as a blinker light, as an instrument light or as a task light.

50. Employment of an illuminating apparatus of one of Claims 1 to 44 in a UV or infrared light.

51. Employment of an illuminating apparatus of one of Claims 1 to 44 in a flashlamp.

52. Employment of an illuminating apparatus of one of Claims 1 to 44 in a stroboscopic light.

53. Employment of an illuminating apparatus of one of Claims 1 to 44 in a traffic light.

54. Employment according to Claim 53 as a hanging signal light or as a warning light.

55. Employment of an illuminating apparatus of one of Claims 1 to 44 in data storage technology or data transmission technology.

56. Method for operating an illuminating apparatus according to one of Claims 1 to 44 having at least one of the steps:

i) selective electrical excitation of predetermined punctiform light source devices in order to achieve brightness modulation;
ii) selective electrical excitation of predetermined punctiform light source devices in order to achieve color modulation;
iii) selective electrical excitation of predetermined punctiform light source devices in order to achieve light-frequency modulation.

57. Colored-light system having at least one illuminating apparatus according to one of Claims 1 to 44 and control electronics for performing at least one of the functions:

i) selective electrical excitation of predetermined punctiform light source devices in order to achieve brightness modulation;
ii) selective electrical excitation of predetermined punctiform light source devices in order to achieve color modulation;
iii) selective electrical excitation of predetermined punctiform light source devices in order to achieve light-frequency modulation.

58. Colored-light system according to Claim 57, characterized in that each individual

illuminating apparatus has its own control electronics integrated therein.

59. Colored-light system according to Claim 58, characterized in that in each case the control electronics contain a color processor.

60. Colored-light system according to Claim 59, characterized in that the color processors are connected to a central processor via a bus line.

61. Colored-light system according to Claims 59 or 60, characterized in that the color processors can be driven in wireless fashion.

Attached: 9 page(s) of Drawings

Drawings

[Running head:]

Drawings, Page XX

Number:	**DE 196 24 087 A1**
Int. Cl.^{6}:	**H 05 B 33/00**
Date opened for public inspection:	December 18, 1997

[Translation includes only those drawings with callouts to be translated.]

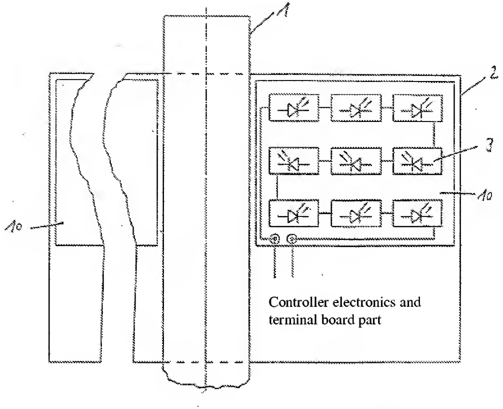

Fig. 3

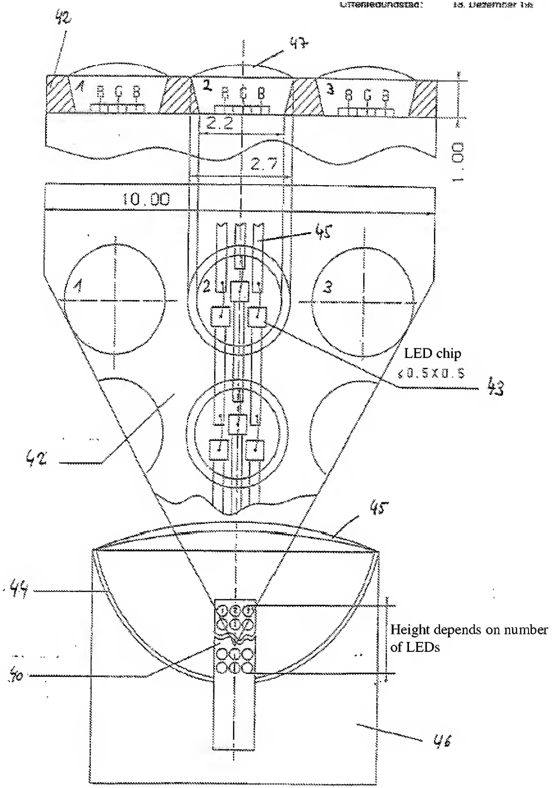
42
47
1
B G B
2
B G B
3
B G B
2.2
2.7
1.00
10.00
45
2
1
1
1
3
LED chip
≤0.5X0.5
43
42
45
44
Height depends on number of LEDs
40
46

Fig. 16

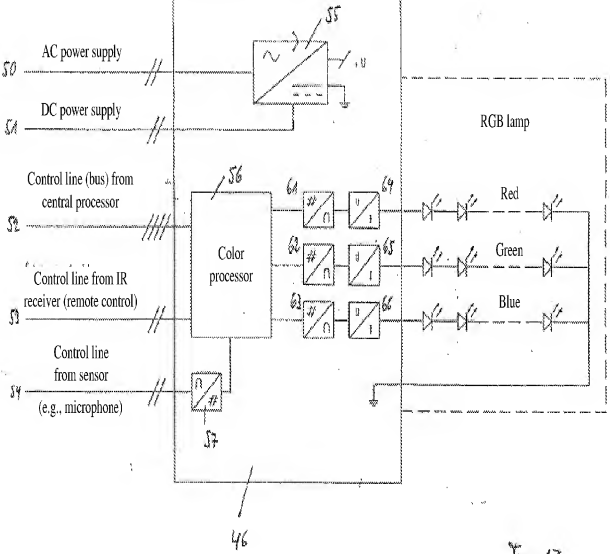
55
AC power supply
50
DC power supply
51
Control line (bus) from
central processor
52
56
61
64
Red
Color
processor
62
65
Green
Control line from IR
receiver (remote control)
53
63
66
Blue
RGB lamp
Control line
from sensor
54
(e.g., microphone)
57
46

Fig. 17

26